COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

September, 1947

Miller's Ford Station, Dayton Power & Light Co.

Combined Steam and Electric Supply in New York

Is Reheat Coming Back?

Test of a Continuous-Discharge Stoker-Fired Unit

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VOLUME NINETEEN — NUMBER THREE

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FOR SEPTEMBER 1947

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

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EDITORIAL

The Future Need for Engineers

Commenting on the future need for engineers, The Engineers' Council for Professional Development, in its recently issued Anniversary Booklet, stresses the existing dearth of adequately trained engineers, which it estimates will be wiped out by 1952 if the present rate of enrollment continues. It also points out the urgent need for more engineers qualified to engage in research and development.

According to the U. S. Bureau of Labor Statistics, approximately ninety thousand engineering students must be graduated in the period from 1946 to 1950 if accumulated requirements are to be fully met. On this basis, the report estimates that by 1950 nearly 46 per cent of all actively engaged engineers will have entered the profession within ten years.

Of the total students enrolled in professional courses in 1940, the last prewar year, about 15 per cent were in engineering. No figures have yet become available as to current enrollments, but it is likely that the popularity of engineering under the G. I. Bill of Rights Educational Program will be found to have raised this percentage.

Quoting from a survey by the American Society for Engineering Education, the booklet shows that employment of engineers increased fifty-six per cent from 1938 to 1946. This, of course, included the war period and can hardly be taken as a normal increase, but it is significant that the employment for research and development was more than twice that of engineers engaged in production, management and sales. This is in line with the further statement by a number of companies that they are now seeking more engineers with advanced degrees.

The recent survey conducted by the Engineers' Joint Council indicated current starting salaries of engineering graduates with a B.S. degree as $1800 to $3000 a year, or a median of $2484, and $3100 after two years' service. Graduates having an M.S. degree command more.

The report of the President's Scientific Research Board, released August 27, 1947, states that the ceiling on research and development in this country is fixed by availability of trained personnel rather than by funds. The sharp reduction in technically trained personnel during the war was probably largely responsible for the fact that, although the total research budget increased 335 per cent from 1940 to 1947, trained manpower increased only 35 per cent during these years.

Expenditures for national research and development (including both private and government projects) during the current year will exceed a billion dollars of which forty per cent will be for military purposes and less than ten per cent for basic research, most of which is now being carried on by universities.

The report further deplores the fact that a shortage of qualified teachers has indicated a deterioration in the quality of scientific training. This will be aggravated as the large number of present freshmen and sophomores reach the more advanced levels.

High Construction Costs Favor Semi-Outdoor Stations

Semi-outdoor power plants have long since ceased to be a novelty. Introduced into the utility field in the early thirties, the first few plants had only the boilers exposed, but later many of the turbine-generators were placed on open decks with only a light removable housing over the turbine end. Certain auxiliaries were outside, but control rooms were enclosed.

With very few exceptions, such installations were confined to localities having mild climates and generally where oil or gas was available as fuel, for certain protective measures were considered necessary when handling coal under adverse climatic conditions. In other words, most of these plants were situated in the South or Southwest; although experience with the few that were located in colder sections of the country demonstrated the feasibility of such designs.

Despite the substantial savings in initial investment and successful operating experiences, many engineers continued to cling to the more or less conventional fully housed type of plant; perhaps more through pride in architectural appearance than for any other reason. However, with ever-increasing material and labor costs in the construction field, there are indications of a still wider acceptance of the semi-outdoor design, not only in the South and Southwest, but also in a number of northern localities; and for pulverized coal firing. In fact, among these installations are three new very large high-pressure central stations under construction—one in New Jersey, another in Ohio, and a third on Long Island.

A feature of outdoor plants that is now becoming common is placement of the fans at approximately grade elevation, so as to make them easily accessible to the operators; and certain new installations in northern climates are expected to use special air-cooled, instead of water-cooled, fan bearings.

Employment of large boilers and turbines, and particularly the single-boiler single-turbine arrangement, has tended to hold down investment in equipment, as well as operating and labor costs, but these are scarcely sufficient to offset the increasing fuel prices; hence reduction in building costs offers an additonal compensating means. Furthermore, the foregoing arrangement makes possible a certain degree of streamlining.

*Combined Steam and Electric Supply in New York**

By W. F. DAVIDSON and M. J. STEINBERG

Consolidated Edison Company of New York, Inc.

In the modernization of Waterside Stations an important factor leading to the selection of topping turbine-generators to replace and supplement low-pressure units was the fuel and capacity savings made possible by the availability of exhaust steam for the district-heating system. With the program only partly completed it was possible during 1946 to supply from turbine exhausts 37 per cent of the total steam requirements with large savings in both fuel and boiler capacity. It is estimated that when the program is completed in 1950 approximately 80 per cent of the district-heating steam can be supplied from turbine exhaust with additional fuel savings and that the less efficient low-pressure steam plants can be shut down for long periods. This paper makes no reference to the other strictly electric-generating stations on the system.

IN 1934 an extensive program was put under way for the modernization of the Waterside electric generating stations of the Consolidated Edison Company of New York. Studies indicated that fuel economies could be realized through a combination of power generation and steam supply for district heating, and this was one of several factors that led to the use of topping turbines.

The Waterside Stations are in two units, Nos. 1 and 2, on adjoining property, and are near Kips Bay, the largest steam generating station of the New York Steam Corporation—a subsidiary of the Consolidated Edison Company. At the time the modernization program was initiated, the two Waterside Stations contained 19 turbine-generators having a combined rated capacity of 366,000 kw of which 19,000 kw was for 60 cycles and 347,000 kw for 25 cycles. Steam was supplied by 146 stoker-fired boilers at about 200 psi and 500 F.

The modernization of Waterside No. 2 was completed in 1941. All the low-pressure boilers were replaced by eight pulverized-coal-fired boilers, four of which supply steam at 1200 psi, 900 F to two 53,000-kw turbine-generators and the other four steam at 1250 psi, 925 F to two 65,000-kw turbine-generators. These turbines exhaust at 200 psi to a low-pressure header which supplies two condensing turbine-generators which were rebuilt for 60-cycle operation and rerated from 30,000 to 40,000 kw. Eight of the original low-pressure condensing turbine-generators were removed.

The modernization program of Waterside No. 1 is still in process. When completed, all of its 54 low-pressure boilers will have been removed and replaced by two 1,000,000-lb-per-hr pulverized-coal-fired units furnishing steam at 1600 psi, 950 F to two 50,000-kw topping turbine-generators. By removals, rearrangements and replacements, there will be six low-pressure condensing turbine-generators with a total rated capacity of 260,000 kw instead of the original nine units having a total of 214,000 kw.

For the two Waterside Stations the final result will be an increase in electrical capacity from 366,000 to 658,000 kw and at the same time (subject to appropriate reduction in electric generation) up to two million pounds per hour of saturated steam at about 175 psi available for district heating.

As no condensate is returned from the steam distribution system, all water represented by the steam send-out must be furnished by makeup from the city water supply, which is of excellent quality and relatively low in hardness (about 50 ppm total solids and 20 ppm hardness) and free from sediment and suspended solids. The raw water is first treated in combination acid-basic-ion exchangers and then degasified by spraying into condensers of the low-pressure turbine-generators. Chemical treatment is conventional, except as modified by large makeup.

While the Waterside Stations constitute part of a system which, when modernization is completed, will total about three million kilowatts, well-defined areas are supplied from particular power stations, and inter-station tie-lines are used normally only to the extent necessary to attain the desired overall system economy.

Also, the steam distribution system is extensive, with two areas of high load density—one in lower Manhattan and the other in mid-town. Because of a distance of about three miles between these two areas and the relatively small existing interconnection, it is not economical at present to transfer large amounts of steam between them. However, at some future time it is planned to install a 24-in. steam main to connect the two areas and to provide a connection to the East River Station which will furnish up to 500,000 lb per hr, in part from turbine exhausts.

The extent to which district-heating steam requirements for the mid-town area can be supplied most eco-

* Abstracted from a paper before the Fuel Economy Conference of the World Power Conference at the Hague, September 2–9, 1947.

nomically from the Waterside topping-turbine exhausts depends, in the first instance, on the relative demands for steam and electric power as expressed in the seasonal and daily load curves. The seasonal range of steam load is considerably greater than that for the electrical load, but the difference tends to become less as more summer air-conditioning load is taken on the steam system. The daily load curves differ noticeably in form, although both have minima during the early morning hours. Determination of the amount of steam to be supplied to the district-heating system is based on economy-loading principles;[1] that is, in using that division of loads among stations and units which will give the minimum overall heat rate consistent with maintaining continuity and quality of service.

Distribution of steam send-out for 1946 and that estimated for 1950 is shown in the accompanying table. In this, Kips Bay (mid-town) and Burling Slip (located downtown) are strictly steam plants and under "other plants" are included the 59th and 60th Street steam plants, as well as several customer plants feeding into the system. The load-duration curves for all these plants in 1946 are shown in Fig. 1, and Fig. 2 represents those estimated for 1950.

[1] Described in some detail in the complete paper, but omitted from this abstract—EDITOR.

DISTRIBUTION OF STEAM SEND-OUT

Year	Station	Installed Net Capacity Lb per Hr	Installed Net Capacity % of Total	Annual Net Send-Out 1000 Lb	Annual Net Send-Out % of Total	Annual Capacity Factor
1946	Waterside*	1,800,000†	20.4	6,468,875	39.9	0.410
	East River*	500,000†	5.7	1,233,567	7.6	0.282
	Kips Bay	2,070,000†	23.5	4,813,985	29.8	0.265
	Burling Slip	1,550,000	17.6	3,254,596	20.0	0.240
	Other Plants	2,885,000	32.8	438,434	2.7	0.017
1950	Waterside*	2,000,000†	18.0	11,867,000	59.3	0.677
	East River*	1,450,000†	13.0	4,175,000	20.9	0.329
	Kips Bay	2,070,000†	18.6	1,647,000	8.2	0.091
	Burling Slip	1,550,000	13.9	1,533,000	7.7	0.113
	Other Plants	4,065,000	36.5	778,000	3.9	0.022

* Electric stations supplying exhaust steam; other plants here listed supply low-pressure steam only.

† Street mains limit the simultaneous send-out from Waterside, East River and Kips Bay to about 85 per cent of the total installed capacity.

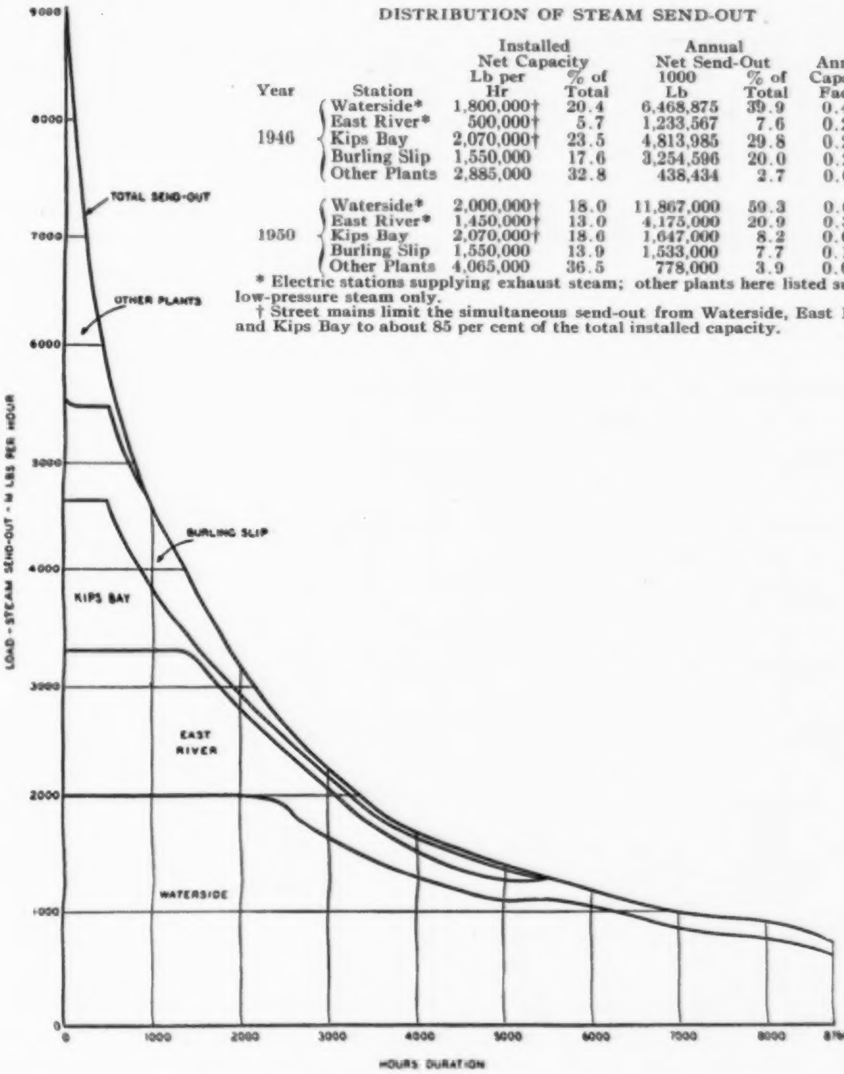

Fig. 2—Estimated 1950 distribution of steam send-out

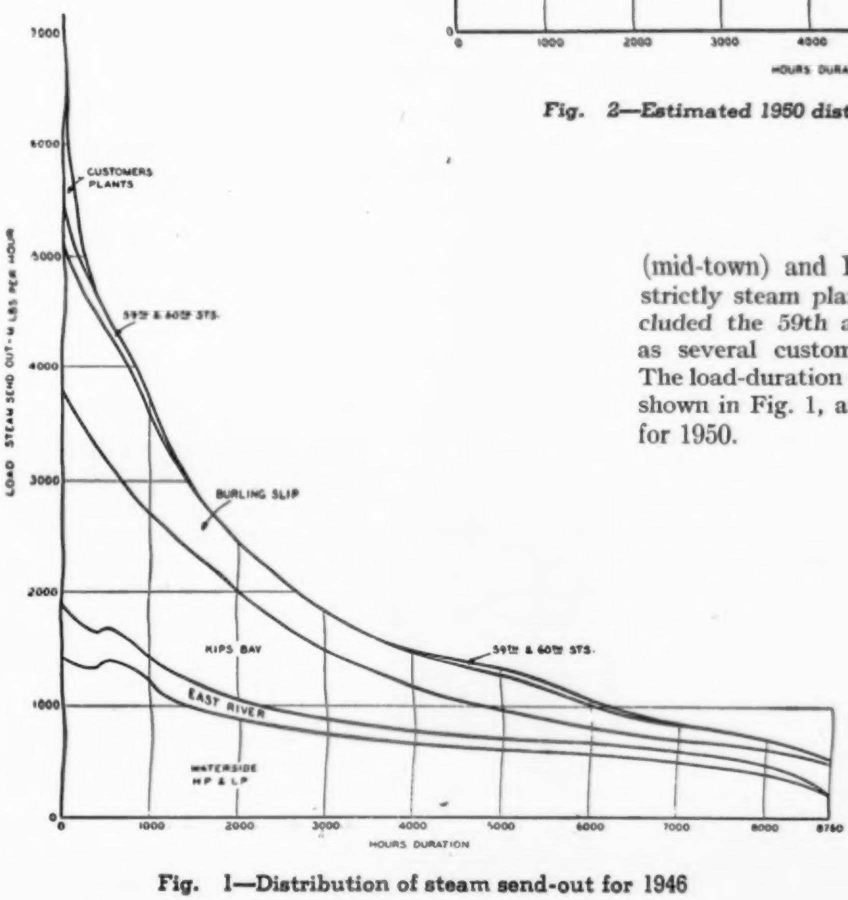

Fig. 1—Distribution of steam send-out for 1946

The 1946 data in the table for Waterside include a small amount (6.7 per cent of the total) of steam sent out direct from the old low-pressure boilers. It will be noted that for 1946, 37 per cent of the steam requirements of the entire district-heating system was met by exhaust steam from the topping turbines at Waterside, and that it is expected this will have increased to 59 per cent by 1950. Steam from East River Station will bring the total to 80 per cent by that time

and will permit shutting down other stations of lesser efficiency for considerable periods.

Aside from a marked improvement in heat rates obtainable with combined operation, it means a reduction in total load on the boilers and a corresponding reduction in needed boiler capacity. The extent of this saving is indicated by reference to Fig. 3 which shows the electric and steam loads on the system for a typical day during the peak season of 1945. For ease of presentation the

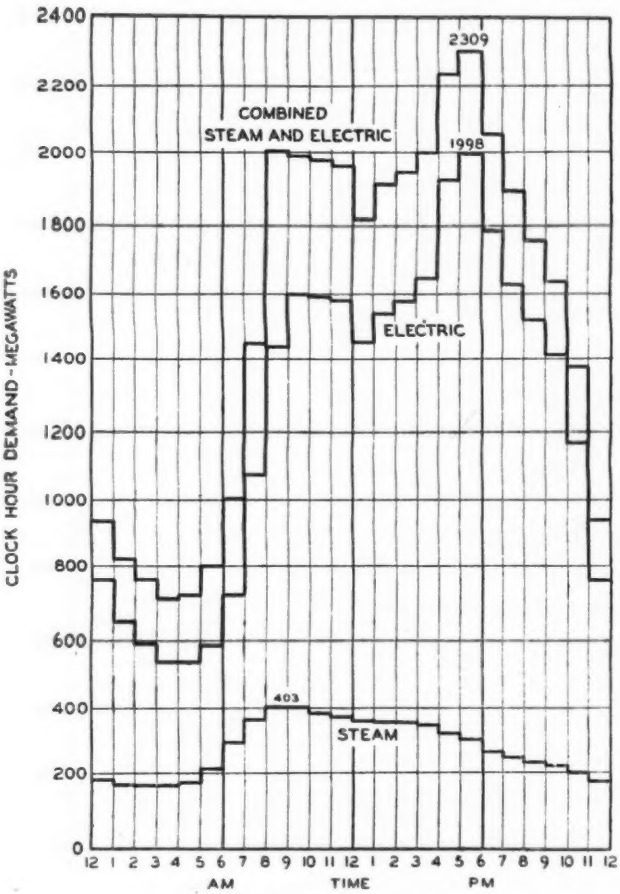

Fig. 3—Typical daily load curves

steam requirements have been expressed in megawatts on the assumption of 12.5 lb of steam per kilowatt-hour. For the conditions shown, the combined steam-electric demand peak is less than the sum of the independent peaks by 92,000 kw, which is equivalent to 1,150,000 lb of steam per hour. Thus by making use of steam from Waterside Station, the steam system may meet its load requirements with a corresponding reduction in operating boilers.

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EQUIPMENT SALES

as reported by equipment manufacturers to the Department of Commerce, Bureau of the Census

Boiler Sales

Stationary Power Boilers

	1947 Water Tube		1946 Water Tube		1947 Fire Tube		1946 Fire Tube	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft	No.	Sq Ft
Jan.	160†	963,949†	173	1,109,924	106	106,788	113	154,064
Feb.	149	939,541†	197	1,262,520	90	99,267	126	171,100
Mar.	168	863,292	171	1,357,650	80	109,984	123	180,552
Apr.	178	1,046,553†	198	1,247,693	71	94,315	110	137,614
May	150	988,794	158	980,004	56	73,821	86	117,554
June	177	1,157,911	151	980,231	49	68,491	99	157,664
Jan.-June, incl.	982	5,990,040	1048	6,938,022	452	552,666	657	918,548

* Includes water wall heating surface. † Revised.

Total steam generating capacity of water tube boilers during the period Jan. to June (incl.), 1947, 73,850,000 lb per hr; in 1946, 60,346,000 lb per hr.

Mechanical Stoker Sales‡

	1947 Water Tube		1946 Water Tube		1947 Fire Tube		1946 Fire Tube	
	No.	Hp	No.	Hp	No.	Hp	No.	Hp
Jan.	67	32,532	61	35,757	148	22,320	184	23,323
Feb.	55	32,759	71	40,880	122	19,946	175	27,708
Mar.	55	26,956	94	45,646	225	29,705	181	28,071
Apr.	63	37,914	93	45,606	114	19,649	249	42,271
May	77	40,481	101	49,653	93	12,500	202	30,933
June	83	38,204	76	42,259	187	24,964	233	32,815
Jan.-June, incl.	400	208,846	496	259,801	889	129,084	1,224	185,121

‡Capacity over 300 lb of coal per hr.

Marine Boiler Sales

	1947 Water Tube		1946 Water Tube		1947 Scotch		1946 Scotch	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft	No.	Sq Ft
Jan.	2	7,724	2	11,276	—	—	1	590
Feb.	2	1,423	—	—	—	—	—	—
Mar.	5	22,232	—	—	—	—	4	1706
Apr.	11	6,801	18	46,390	—	—	1	263
May	1	4,852	4	9,040	—	—	1	263
June	1	688	31	17,620	1	1290	1	520
Jan.-June, incl.	22	43,720	55	84,326	1	1290	8	3342

* Includes water wall heating surface.

Total steam generating capacity of water tube boilers sold in the period Jan. to June (incl.), 1947; 729,000 lb per hr; in 1946, 674,000 lb per hr

IS REHEAT COMING BACK?

Increasing fuel prices appear to be responsible for a revival of interest in the reheat cycle as a means of attaining added thermal economy, in view of diminishing returns from further pressure-temperature increases with the straight regenerative cycle. The present trend toward the unit arrangement of boiler and turbine is particularly adapted to employment of reheat as it avoids some of the previous operating complications of that cycle. A number of the earlier reheat installations are reviewed briefly.

OF eighty new central-station installations built, under construction, or projected, as listed in *Power* of June 1947, fifty-eight have one boiler per turbine. This current trend toward wider use of the unit system may be traced to several factors, one of the most important among which is that experience has shown modern boiler and turbine availability to be generally comparable and in the range from 90 to 95 per cent. In fact, at Port Washington Station of the Wisconsin Electric Power Company, which has always followed the unit system, the 10-yr average boiler demand availability[1] was 96.5 per cent and the turbine demand availability 92.7 per cent.

In a paper before the 1947 Summer Meeting of the A.S.M.E. at Chicago, E. H. Krieg pointed out that one of the major economies in power plant first cost is adoption of the single-boiler, single-turbine combination, provided special attention is given to availability and reserve capacity; but that continued high availability up to about 95 per cent is attainable only if the initial design is pointed toward that objective. "Designing for high availability," he continued, "costs more, as the lower heat-transfer rates in the boiler require more surface and more liberal proportioning of equipment. But such extra costs for single-boiler, single-turbine installations are in most cases well justified as the improved availability permits decrease in reserve capacity; the unit cost of equipment generally decreases with increased size; building and foundation costs are less with the single boiler; operating costs are likely to be less; and maintenance costs usually are less as the size of the unit increases."

There is still reluctance on the part of some companies, especially those pressed for capacity, to adopt the unit arrangement unless cross-over connections are installed, lest the turbine of one unit and the boiler of another be out at the same time. In some stations provisions are made for operating the low-pressure turbine with steam from the high-pressure boiler if the high-pressure turbine is out of service, even though this entails some added complications.

Unit System Adapted to Reheat

The unit arrangement also offers certain advantages for the employment of the reheat cycle which appears to be coming to the front again after a lapse of some years. Commenting upon the quoted observations of Mr. Krieg, Sabin Crocker remarked that "Interest in the unit system is bound to increase because of its application in the reheat cycle which is becoming more attractive owing to increasing fuel prices coupled with diminishing returns from further pressure-temperature increases in the straight regenerative cycle."

Reheat is by no means new to American engineers, many of whom gained much experience with its use in a number of the older stations. For a considerable period, however, it gave way to the steadily increasing steam temperatures as a means of achieving desired economy and dryness of steam in the low-pressure stages of the turbines. A brief review of some of these earlier installations may be in order at this time in view of the revived interest.

Early Reheat Installations

Employment of the reheat cycle by central stations in this country dates back to the middle 20's at which time a number of 600-psi, 750-F plants were laid down, and are still in service. These included Philo, Twin Branch, Crawford Avenue (Chicago) and Columbia (Cincinnati) which were built in 1924 and 1925. Steam conditions at the turbine throttle were 550 psi, 725 F with gas reheat to 700 F at 105 psi pressure. Also, these stations were among the earliest in this country to employ the regenerative cycle for feedwater heating.

In explaining why reheat was adopted for such steam conditions, W. S. Monroe, then president of Sargent & Lundy, the consulting engineers responsible for the design of these stations, stated in a paper before the 1924 World Power Conference that with 550 psi, 700 F initial steam conditions and no reheat, moisture would begin to appear in the turbine as 55 psi was reached, and that it would be necessary to have an initial steam temperature of about 1000 F if excessive moisture were to be avoided in the lower turbine stages. But at that time metallurgy had not advanced sufficiently to warrant such a high temperature, hence reheating was adopted. He estimated that the conditions employed represented a gain of more than 15 per cent over the 275 psi, 565 F which was common in stations at that time; and the gain attributable to reheating alone at 550 psi, 725 F to be between 5 and 6 per cent, based on a pressure drop through the reheater of 10 to 12 lb. Actually, subsequent tests at Philo, however, were reported in the technical press to have shown a steam consumption of 9.6 lb. per kwhr without reheat and 8.18 with reheat—a gain of approximately 15 per cent.

[1] For complete performance figures see COMBUSTION of January 1947.

Three or four years later State Line Station followed with similar steam conditions, but employed live steam reheat at the turbine.

Also, during this period reheat appeared in connection with several higher-pressure stations in the 1200-psi range. Among the first of these was Edgar Station of the Boston Edison Company which, in 1925, installed a 15,000-kw topping turbine-generator taking steam at 1200 psi, 700 F and exhausting through a gas heater, integral with the high-pressure boiler, to the 350-psi station header. Reheat was carried to the initial steam temperature. The high-pressure boiler and turbine were operated as a unit.

In 1928–1929 gas reheat was employed between two 1200-psi, 725-F, 12,000-kw high-pressure turbine-generators and two 41,000 low-pressure units at the Deepwater (New Jersey) Station. At about the same time the 1200-psi, 750-F Holland Station (later named Gilbert Station) employed reheat at 400 psi, 750 F for its high-pressure turbine exhaust. Here both integral gas reheating and steam reheating were installed in series, the latter to insure regulation of reheated steam temperature over the operating range. It is understood, however, that the latter complication was subsequently found unnecessary. A somewhat similar plan was adopted for the South Amboy Station.

Port Washington, the first section of which was designed in 1929–1930 but not completed until 1935, employs a radiant reheater located in the furnace walls. Here the operating steam conditions at the turbine throttle are 1200 psi, 825 F, the steam between the high- and low-pressure elements of the 80,000-kw turbine-generator being reheated to the initial temperature. Reheat has continued to be employed in all subsequent extensions to this station, although the reheater arrangement for the most recent extension is still in the design stage.

Live steam reheat was originally employed at the Rouge Power Plant of the Ford Motor Company, but when installing the last two 110,000-kw high-pressure units a change was made to the straight regenerative cycle without reheating.

Still another well-known gas reheat installation is that in the 1825-psi, 960-F forced-circulation boiler at the Somerset Station of the Montaup Electric Company where exhaust from the topping turbine is reheated to 765 F before passing to the low-pressure plant.

Changed Conditions Favor the Reheat Cycle

There were still other reheat jobs of that period but the above-mentioned installations will serve to indicate its relatively wide acceptance from 1924 through 1930. However, with very few exceptions, for the next fifteen years or more little attention was given the reheat cycle. This may have been due to several factors, such as the steady increase in steam temperatures accompanying advances in metallurgy; to an era of topping installations in the middle and late 30's under conditions in which reheat offered little economic advantage to offset the added complication; to the design of many stations for moderate steam conditions of around 900 psi and 900 F; and to the fact that fuel prices had not yet started a steady climb. However, the economic situation has now changed to the extent that a revived interest is being shown in the reheat cycle, combined with high pressure and temperature, in an effort to attain further economy.

At one time it was contended by some engineers that the thermal gain due to reheat in conjunction with both very high pressures and temperatures would be insufficient to justify its use under such conditions; but more recent opinion appears to lean to the view that in some such cases it is fully warranted. In this connection, a study by R. H. Tingey on high-pressure for marine propulsion[2] showed that with steam at 1425 psi and 940 F, reheat would show a gain of approximately 6 per cent over the same steam conditions without reheat.

New Reheat Installations

Among the new installations that are being designed to employ the reheat cycle are the 2300-psi, 1050-F Sporn Station (A. G. & E.), the 1600-psi, 1000-F extension to Edgar Station and the latest extension to Port Washington, all of which will employ the single-boiler, single-turbine arrangement. In England two new installations, Dunstan B and Littlebrook B, are using reheat with the moderate steam temperature of 850 F. Studies of the reheat cycle are also being made in connection with several other projected installations.

It may be in order to recall that with gas reheat, steam from the high-pressure turbine exhaust can be brought up to the initial temperature in contrast with live-steam reheating. In the latter case the resuperheating can be carried little higher than the saturation temperature corresponding to the initial pressure, owing to the need for condensing the live steam in the reheater so that it can be pumped back to the boiler. This limitation outweighs its advantage of lower piping cost and greater simplicity of operation. Also, pressure drop for a live steam reheater is somewhat less than that for gas reheat, because of the lesser volume of the high-pressure steam carried by the piping.

In some marine installations where reheat has been employed a separately fired reheater, integral with the boiler, has been used to provide the required operating flexibility. However, a separately fired gas reheater for stationary service would appear to introduce excessive complications. In many stationary installations control of the reheat temperature is brought about by desuperheating. Another simple and effective means is an arrangement whereby control can be effected through dampers regulating the gas flow over the superheater and reheater. Such an arrangement possesses the advantage of being able to protect the reheater when starting up, although this is sometimes accomplished by running a line from the steam drum to the reheater inlet.

One difficulty with reheat when two or more boilers supply a single turbine is to distribute the reheated steam properly to the individual boilers in proportion to the quantities they are generating. This involves some means of setting up resistance in the piping such as valves. With a single-boiler, single-turbine unit this problem is not encountered. In fact the Edgar design employs only a minimum of piping and no valves other than that at the turbine. Reheat temperature control will be effected by a desuperheater at the inlet.

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[2] A paper before the New England Association of Naval Architects and Marine Engineers, reprinted in COMBUSTION, January 1944.

Steam Generation and Gas Turbine Developments in Switzerland

The U. S. Bureau of Mines has recently issued Information Circular 7403 containing a report on "Recent Engineering Developments in Switzerland on Gas Turbines and Steam Generators," by Dr. H. J. Rose, Vice President and Director of Research of Bituminous Coal Research, Inc., who, as a member of a technical mission to Europe after the war, was subsequently permitted to visit neutral Switzerland to obtain information on fuel and power developments. Following are excerpts from the report.

THE purpose of this investigation was to ascertain what progress had been made in Switzerland during the war years in developing equipment for the more effective utilization of coal. This included the use of coal for firing gas turbines, the burning of coal under pressure in Velox boilers, recent developments in the "Monotube" high-pressure boilers, combined heating and power plants, and the commercial development of the heat pump. The principal firms visited were Brown, Boveri & Co., Escher Wyss Engineering Works and Sulzer Bros.

Gas Turbines

While each of these firms is actively interested in gas turbines, Brown Boveri is the only one experimenting with the use of coal for firing them. In this connection considerable progress has been made experimentally in burning coal under pressure to obtain combustion gases having a reduced content of solid particles, and in designing turbine blades that show minimum erosion from such particles. However, tests now in progress will likely have to be continued for some time before the company would be justified in designing a full-sized coal-fired combustion turbine plant for commercial use.

About forty gas turbines have been built by this company or are on order throughout the world for use with the Houdry process or oil-fired for power generation, exclusive of those serving Velox boilers.

Escher Wyss has developed a closed circuit "aerodynamic" turbine in which the working medium is air circulated under pressure. This feature permits the design of units of large output and of nearly constant efficiency over a considerable load range. Inasmuch as the products of combustion do not pass through the turbine, any fuel can be used provided the heating surfaces of the heat-exchanger can be kept satisfactorily clean and in good condition. The only turbine of this type constructed to date is a 2000-kw unit installed in the company's plant which under test, with entering air at 1288 F and 343 psi maximum pressure, showed a thermal efficiency of 31.5 per cent at full load and 29.6 per cent at half load, based upon the net heating value of the oil as fired. These thermal efficiencies would be somewhat lower if calculated on the gross heating value, in accordance with American practice. Subject to establishing a satisfactory source of supply of alloy tubes for the heat-exchanger, the company was prepared to offer much larger aerodynamic turbines in sizes of 6000, 12,000 and 25,000 kw. Preliminary studies are being made on the application of the aerodynamic gas turbine to locomotives. Such a turbine fired with blast-furnace gas to drive blowers is under consideration.

Sulzer Bros. had under construction a 7000-shp, oil-fired marine gas turbine which was said to possess certain advantages of the closed circuit without the necessity of employing a large heat-exchanger. Not much consideration had been given to using coal as fuel for this turbine.

Steam Generators

As is well known, in the Velox steam generator fuel is burned under a pressure of 2 to 3.5 atmospheres and the products of combustion pass through a gas turbine which drives a compressor supplying the combustion air. Steam is produced at 25 to 35 atmospheres (367.5 to 514.5 psi) and 425 to 450 C (797 to 842 F). So far only oil and gas have been employed to fire Velox boilers, although Brown Boveri have been studying the combustion of coal under pressure for several years, and development work along this line appears to be approaching the point where construction of a full-scale unit for industrial application will be considered. In fact, both high-volatile, high-oxygen coking coal from the Saar District and medium-volatile, strongly coking coals from the Ruhr have been burned successfully in pilot-plant tests at Baden.

The Sulzer "Monotube" steam generator, brought out several years before the war, consists of one or more continuous welded tubes several thousand feet long in which the feedwater is preheated and evaporated and the steam superheated. The continuous tube is bent to form banks of preheater and superheater tubes, as well as furnace walls. Each tube is capable of producing about 20,000 lb of steam per hour, so that for large capacities several tubes are employed and bent to lie parallel. At the end of the evaporative zone there is a continuous blow-down to maintain the concentration within certain limits.

This type of unit is recommended as best suited for steam pressures in excess of 80 atmospheres (1176 psi) and the highest pressure in service to date is 140 atmospheres (2058 psi). The steam temperature in most installations is around 930 F, although Sulzer has designs for this type of boiler to operate at 1112 F.

A total of fifty-one such units are now operating in various European countries or are under construction. Of these forty-two are coal fired and the remainder oil or gas fired. Most of these are superimposed installations. For pulverized coal firing Sulzer Bros. has adopted generally, tangential corner firing.

Combined Heating and Power Plants

All three of these companies were found to be interested in installations in which the overall efficiency of heat utilization is increased considerably by using the energy partly for power and partly for heating; that is, through the use of back-pressure turbines with exhaust steam for heating or process, or cooling water from pre-coolers and compressor water-coolers of gas-turbine plants at a temperature high enough for heating or hot water. One test was cited to show that such heat recovery amounted to about 46 per cent of the total heat in the fuel burned.

Heat Pumps

Owing to a favorable combination of circumstances in Switzerland, heat pumps have received much commercial development of late for comfort heating and cooling in public and private buildings, as well as for certain commercial applications of drying and evaporation. That is, abundant hydroelectric power is available and the heat-pump principle is employed to multiply the heating effect of the electricity because of the coal shortage resulting from the war.

In this process low-head heat is extracted from a cold lake or river and delivered at a temperature sufficiently high for comfort heating or other purposes. In typical installations cited about two-thirds of the useful heat comes from the water supply and one-third from the electric power. However, in the case of radiation and panel heating, which employs lower temperatures, as little as one-fifth of the heat may be supplied by the electric power; and in certain industrial evaporative processes that employ small temperature differentials, a still higher ratio of useful heat to power input is established.

The Brown Boveri plant at Baden is heated by a heat pump system utilizing river water. Also, such a system is used to supplement the central heating power plant of the Swiss Federal Institute of Technology at Zurich where hot water at 154 to 165 F is produced from river water of 36 to 61 F. Air conditioning in one Zurich building is obtained from a heat pump supplying 200,000 Btu per hr when heating and extracting 108,000 Btu per hr when cooling. Other installations noted were an artificial silk plant where hot process water at 136 to 158 F was obtained from cold lake water; a paper mill where hot air for drying was similarly obtained; as well as food-preparation and chemical plants.

On the economic side, it was pointed out that, owing to the high initial cost of heat pumps and the variable daily heat requirements for comfort heating, it is usually considered preferable to design the heat pumps for the base heating load and to use a supplementary source of heat for peak demands. For instance, in the Zurich Town Hall, where the same heat pump, operating on river water, serves for heating in winter and cooling in summer, heating-water storage tanks are installed for peak heating.

A 24-hr test of this 80,000-lb-per-hr unit showed an overall efficiency of 85.46 per cent on a weighed and metered basis and 83.94 per cent on a heat-balance basis. At full rating the CO_2 leaving the boiler was 13.9 per cent. Carbon losses amounted to 0.61 per cent in the ash pit and 1.61 per cent in the cinders and leaving gases. At all times, even at 20 per cent above rating, the stack discharge was within Ringlemann No. 1.

By M. O. Funk
Combustion Engineering Company, Inc.

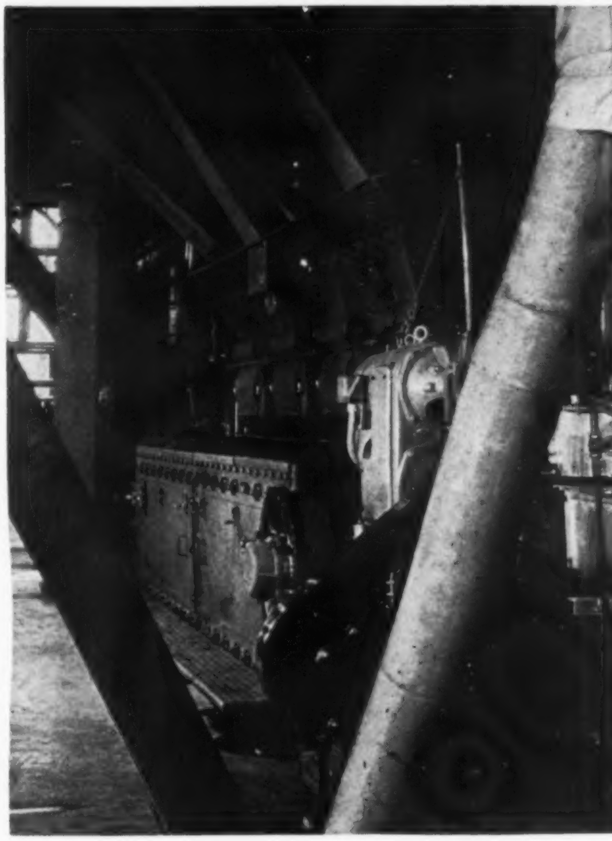


Fig. 1—Front end of stoker

Test of a Continuous-Discharge, Spreader-Stoker-Fired Unit

SEVERAL months ago at the Victor Chemical Works, Chicago Heights, erection was completed of an 80,000-lb-per-hr steam generating unit fired by a spreader stoker of the continuous ash-discharge type. The unit was given a 24-hr acceptance test on May 19, and although not conducted under ideal test conditions, the overall results exceeded the guaranteed performance. The figures are here given as an example of what may be expected of a unit of this size and type with comparable steam conditions, as applicable to many industrial plants.

The boiler is of the two-drum C.E. VUX type with plain-tube water walls and equipped with an economizer, as shown in the cross-section, Fig. 4. The setting is steel encased. Initial operating pressure is only 275 psi, without superheat, but the design contemplates future operation at 450 psi and installation of a superheater to provide steam at 750 F. Heating surface is distributed as follows: boiler 8830 sq ft, water walls 890 sq ft, economizer 3250 sq ft; and the furnace volume is 4650 cu ft. With 100 per cent makeup the temperature of water entering the economizer on test was 245 F.

The C.E. continuous-discharge spreader stoker is 14 ft wide by 16 ft overall length, has four feeder units and a grate area of 224 sq ft. Ash discharge from the traveling

TEST DATA

	Test	Predicted
Actual water evaporated, lb/hr	81,854	80,000
Rate of coal firing, lb/hr	8,818.8	9,600
Steam pressure in boiler drum, psia	291.8	289.7
Steam temperature at saturated header, F	408.7	....
Water temperature entering economizer, F	245.1	215
Water temperature leaving economizer, F	303.5	281
Temperature air for combustion, F	72.1	....
Ambient air temperature, F	80	....
Gas temperature leaving boiler, F	580.7	650
Gas temperature leaving economizer, F	390.9	424
Draft in furnace, in. H_2O	0.125	....
Draft loss through boiler, in. H_2O	1.06	1.00
Draft loss through economizer, in. H_2O	1.82	1.52
CO_2 leaving boiler, %	13.9	13.5

Proximate Analysis of Coal as Fired

Moisture	10.5%	Btu per lb	11,103
Volatile matter	35.2%	Combustible in ash pit refuse	4.7%
Fixed carbon	41.8%	Combustible in cinder collector refuse	30.5%
Ash	12.5%		
Total	100.0%		

Efficiency Calculations

Enthalpy of saturated steam, Btu/lb	1202.95
Enthalpy of water to economizer, Btu/lb	213.51
Heat absorbed per lb of steam, Btu/lb	989.44
Heat absorbed by steam, 10^6 Btu/hr	80.989
Heat absorbed by blowdown, 10^6 Btu/hr	2.689
Total heat absorbed, 10^6 Btu/hr	83.678
Total heat input, 10^6 Btu/hr	97.915
Efficiency, %	85.46
Guaranteed efficiency, %	80.7

Heat balance, %

Loss due to dry gas	7.47
Loss due to H_2 and H_2O	5.35
Loss due to combustible in refuse	2.42
Loss due to radiation	0.82
Total losses	16.06
Efficiency by difference	83.94

Fig. 2—Cinder recovery header

grate is at the front and the undergrate air is compartmented. Overfire air jets are introduced tangentially from all four corners of the furnace at a static pressure of 35 in. A cinder-recovery system re-injects the cinders above the rear of the grate and they have an opportunity to burn out before reaching the ash discharge.

Coal Analysis

The coal burned is an Indiana bituminous containing on proximate analysis as fired, 10.5 per cent moisture, 35.2 per cent volatile, 41.8 per cent fixed carbon and 12.5 per cent ash, with a heating value of 11,103 Btu per lb. The size classification, as furnished by the mine, is 100 per cent through a $1^1/_4$-in. round-hole screen, 4 per cent on 1 in., 16.6 per cent on $^3/_4$ in., 47.8 per cent on $^1/_4$ in. and 31.6 per cent through a $^1/_4$-in. hole.

During the test, coal from the overhead bunker was discontinued and the coal was weighed in 150-lb wheelbarrow lots which were deposited on a platform at the front of the stoker and from here shovelled into the stoker hopper. The hopper was level full at the beginning and end of the test, as well as at hourly intervals during the test.

The test and predicted data are given in the accompanying table from which it will be noted that an overall efficiency of 85.46 per cent was attained on a metered steam-flow and weighed-coal basis, and 83.94 per cent on a heat-balance basis. Both these figures exceeded the guaranteed efficiency.

At an average grate heat release of 436,000 Btu per sq ft per hr the CO_2 leaving the boiler was 13.9 per cent, or 0.4 per cent higher than predicted. Unburned combustible in the ash pit refuse was 4.7 per cent and that in the cinder collector refuse was 30.5 per cent. The resulting carbon losses were calculated as 0.61 per cent in the ash-pit refuse and 1.61 per cent in the cinders and gases leaving the economizer.

Control of the undergrate air at the front compartment was especially beneficial. Through the entire range of output the stoker was operated with the front compartment damper closed, since the fire was burning out about 2 ft inside the front line of the stoker. The ash discharging into the ash pit under these conditions was about 2 in. thick as it came off the grate and there were no signs of clinker formations.

Fig. 3—Idler shaft and means for adjusting tension on moving grate

Overload Test

At the end of the 24-hr test period the steam output was increased to 100,000 lb per hr for about 30 min. This output required a grate heat release of approximately 550,000 Btu per sq ft per hr. Performance under these conditions was good, although the smoke discharge from the stack was slightly heavier while stepping up the steam flow. However, after conditions became stable the stack discharge decreased to that comparable with Ringlemann No. 1. The fuel bed remained light and porous with no evidence of clinker during the overload operation.

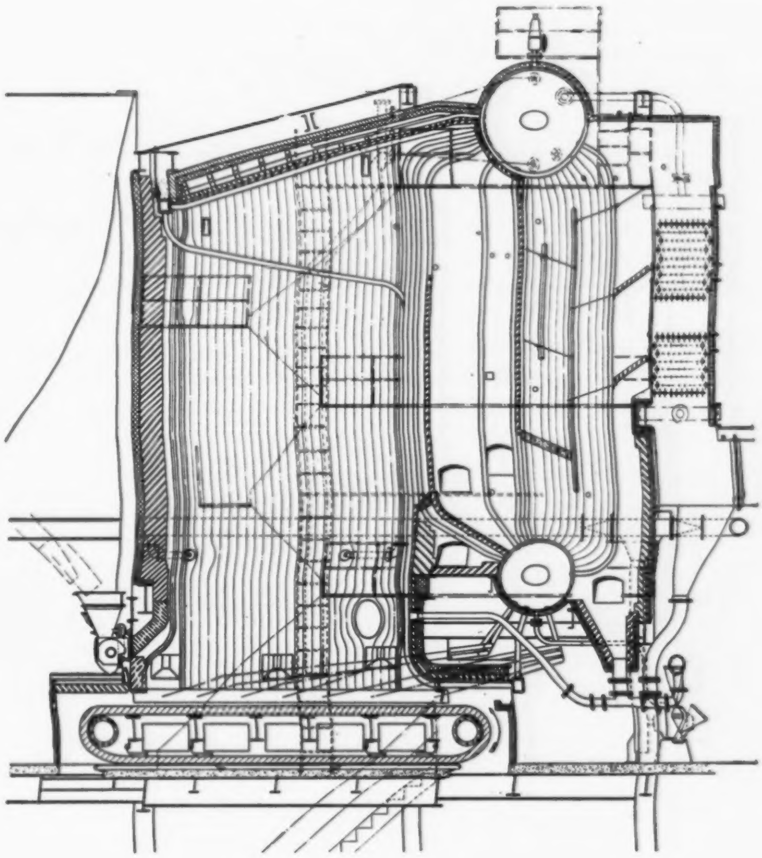
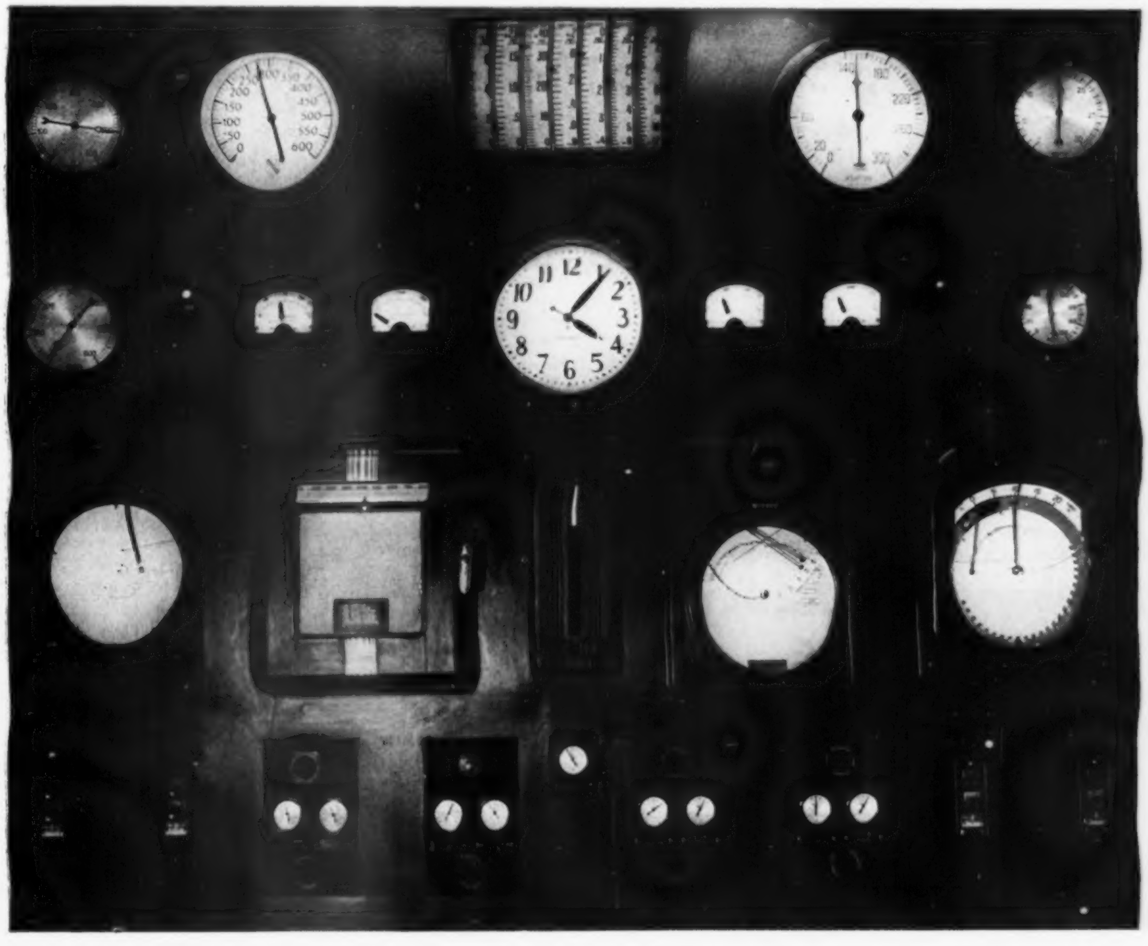


Fig. 4 (right)—Cross-section through unit showing cinder recovery and reinjection system

Fig. 5 (below)—Control board for the unit



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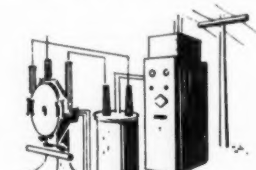
▶ *Western Precipitation Corporation is the organization that installed the first successful* COTTRELL *Precipitator over 39 years ago, still operating efficiently . . . and has consistently developed new refinements, new techniques, new applications that today have made it world famous in the science of recovering dusts, fly ash, mists, fogs and other suspensions from gases.*

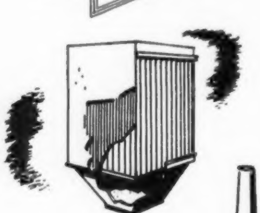
This is the first of a series of advertisements briefly outlining the important elements that go to make up a COTTRELL installation. Only long experience coupled with highest engineering ability, can assure the proper combination of these elements into a COTTRELL installation best suited to *your particular requirements!*

Basically, a Cottrell Precipitator consists of three major divisions each in turn consisting of many separate elements . . .

1. THE ENERGIZING SYSTEM, as its name implies, is the portion of the unit wherein the power is brought in, the voltage stepped up, then rectified to provide the unidirectional high voltage current supply for the Electrode System.



2. THE ELECTRODE SYSTEM consists of the high-tension ionizing electrodes and collecting electrodes through which the suspension-laden gas is passed to be cleaned. These electrodes can be of various designs, shapes and patterns and are equipped with various "rapper" arrangements which assist in keeping the electrodes clean of recovered materials.



3. THE HOUSING OR SHELL includes the structure containing the Electrode and Energizing Systems as well as the gas ducts and distributing system, the hoppers for receiving the collected material and other miscellaneous equipment.

Each of these three major divisions, together with their many individual parts, must be carefully engineered into ONE integrated and precisely-balanced unit to provide the successful and continuously-operating COTTRELL Precipitator. This series will take these major units apart to show in greater detail how the individual parts function and the varying types of design and construction. Watch for them.

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8. **ANY CAPACITY** — handle a few c.f.m. — or millions — with equal ease.
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Mechanism of Combustion of Pulverized Coal

The following are excerpts from a paper by A. A. Orning, of the Carnegie Institute of Technology Coal Research Laboratory, presented at the Pulverized Coal Conference held at Harrogate, England, June 2 to 6, 1947. The full paper contains a complete description of the apparatus and the procedure employed which is here omitted, as well as certain other details and observations. Quotation from the paper is made through permission of the Secretary of the Institute of Fuel under the auspices of which the Conference was held.

CONDITIONS under which good combustion can be attained are reasonably well known, but knowledge of what happens to an individual coal particle has developed rather slowly. Information was needed to confirm the assumption that a coke residue burns subsequent to the evolution and combustion of the volatile content; also regarding the size and form of this residue as related to the size of the original coal particle.

A study of the burning of individual particles of coal in air suspension was initiated for the purpose of supplying these missing points of information and of providing a more complete picture of the mechanism of combustion. While it was desirable to carry out these studies under conditions as nearly as possible like those in a furnace, there was no means of singling out a particle of known size and following it through a pulverized coal flame. For these reasons an electric furnace was used into which a stream of particles of known size and character could be introduced. Also, it was arranged to control the gas currents within the furnace so that the burning particles could be swept through with various velocities, and not be allowed to come to rest upon any surface hot enough to permit continued combustion. Provision was made for collecting and examining the residues swept through the furnace.

Photographic records of the burning particles were made with a special camera fitted with a 107-mm, F 3.7 Kodak Anastigmat-Ektar lens, with the film moving past the lens at a steady rate of 275 in. per min. A rotary disk shutter was driven at 1800 rpm and the exposures were such as to stop effectively the motion of both the film and the falling particles. Two identical series of sector openings were employed and the result was a series of images for each particle forming a trace diagonally across the film.

The proximate analyses of the coals used for most of the investigations are given in Table 1, whereas the volatile matter on an ash-and-moisture-free basis, the ash contents and the mesh size for some of the samples is contained in Table 2.

Ignition

The most important data resulting from the investigations were from examination of the residual particles after exposure to various furnace temperatures. In particular, as applied to Pittsburgh Seam coal, 60 to 80 mesh, 1.29 float, the particles showed some melting and took on a bright pitch-black surface at 500 C. As the temperature was raised, the size of the residual particles passed through a maximum at 750 C for this coal, and upon microscopic examination were found to be cenospheres, having no internal structure but quite irregular in form. It appeared that the basic cenosphere formed a hardened shell before the fluid material was all eliminated. Internal pressure then caused this fluid to escape through weak points in the shell forming hollow nodules which sometimes ruptured. Whenever the furnace temperature was so low that ignition did not generally occur, as judged by infrequent visible flashes, the residual particles showed a bright pitch-black appearance. At sufficiently high temperatures the flashes became more frequent and practically every particle showed evidence of ignition. Particles that had ignited, but were not completely burned, lost their bright pitch-black color and assumed a graphite gray.

TABLE I—PROXIMATE ANALYSES OF COALS USED

Seam	Mine	Moisture, Per Cent	Volatile, Per Cent	Fixed Carbon, Per Cent	Ash, Per Cent	Btu per Lb
Pittsburgh	Edenborn	1.9	33.6	57.0	7.5	13,910
Pocahontas No. 3	Pinnacle	0.8	15.3	78.3	5.6	14,760
Illinois No. 6	Orient No. 1	6.7	33.9	50.3	9.1	12,270
Kanawha	...	1.4	32.5	56.3	9.8	13,260

TABLE II—ANALYSES OF COALS AS USED

Seam	Mesh Size	Density, F	Ash Per Cent	Volatile* Per Cent
Pittsburgh	40 to 50	1.29	1.78	39.30
	60 to 80	1.29	1.84	39.20
Pocahontas No. 3	60 to 80	1.35	2.37	18.83
	80 to 100	1.35	2.60	18.70
	100 to 140	1.35	2.24	19.48
	140 to 170	1.35	2.45	19.35

* On an ash-and-moisture-free basis.

The ignition process was also observed in a miniature furnace, under a microscope. An individual particle, of about 40- to 50-mesh size, was placed on a refractory pedestal in a furnace that could attain 950 C (1742 F) within two seconds. Ignition was preceded by cenosphere formation. Sudden rupture and nodule

formation sometimes caused the particle to turn over and even fly off the pedestal.

The sequence of cenosphere formation and ignition could not be observed in the large furnace, but the ignition and burning of volatile matter was quite evident. The initial portions of the photographic records clearly show the volatile matter burning as a candle-like flame.

Temperature required to bring about ignition depended upon the nature of the coal sample. Pittsburgh Seam coal, 60 to 80 mesh and 1.29 float, was not uniformly ignited below 850 C (1562 F), whereas Pocahontas Seam coal, 60 to 80 mesh and 1.35 float, required a somewhat higher temperature of 900 C (1652 F); and a 60- to 80-mesh sample of anthracite could not be ignited at 950 C (1742 F), but showed good ignition at 1400 C (2552 F) when exposed to this temperature for about a tenth of a second.

Ignition of the solid residue was not conditioned upon the prior ignition of the volatile matter. Moreover, as the density of the coal stream slowly increases, a definite flame front may suddenly appear, while at lower densities the particles ignite independently at various levels in the furnace. With increasing density all of the particles may begin to ignite at the same level which moves up and down with changing cloud density or air velocity. This effect led to considerable difficulty at lower temperatures and especially with coal that was difficult to ignite.

That portion of the heat released by combustion of the volatile matter is very important. It is released near the burner where an intense flame is desirable.

Indications were that combustion of the coke residue depends upon the transport of some oxidizing gas to the burning surface. This gas could conceivably be other than oxygen. That is, a system involving gasification by carbon dioxide, producing carbon monoxide which reacts with oxygen in the gaseous envelope has already been postulated. However, while it would be interesting to know the exact nature of the surface reactions, it appears that gaseous transport rather than chemical resistance is the controlling factor.

Rate of Gasification Increases with Velocity

The work of Tu, Davis and Hottel shows that as the temperature rises there will generally be a temperature dependent upon the air-flow pattern over the surface, beyond which the rate of gasification no longer follows an Arrheinus curve. The rate of gasification becomes only slightly dependent on temperature, and at any given temperature it increases with gas velocity.

Observations have led to the conclusion that a particle of pulverized coal can maintain the desired high burning rate only so long as it can maintain a high temperature which is much higher than that of the furnace walls, except possibly in slagging furnaces.

It was thought that it might be possible to stop the burning by increasing the air-flow velocity so that the particles would pass out of the furnace before they had time to burn to completion, the object being to ascertain the effect of the time of exposure to furnace temperature upon the degree of combustion. This experiment, applied to Pittsburgh Seam coal 40 to 50 mesh, 1.29 float, showed that the degree of combustion was only slightly dependent upon the portion of the total burning time during which the particles remained in the furnace. In fact, the substitution of an environment at room temperature for the hot furnace had little effect upon the subsequent course of the combustion process. This could only mean that the particles were so much hotter than the furnace that substitution of room temperature for hot furnace temperature did not appreciably increase the rate of heat loss.

Radiation Effects

Radiation was the most important mode of heat loss. The back radiation from a heat-receiving surface at 950 C is less than one-fourth the direct radiation from a black body surface at 1500 C. Allowing the 1500-C surface to radiate to room temperature would practically eliminate the back radiation and increase the rate of heat transfer by one-third. Such calculations would indicate that the temperature of the burning particles is in excess of 1500 C.

While substitution of a lower surrounding temperature had little effect upon continuation of the combustion process, the furnace temperature did have an effect upon the degree of combustion, and it appeared that different furnace temperatures changed the character of the residual particles that had to be burned. That is, experiments in which closely sized coal particles were passed through the furnace at various furnace temperatures showed that the size of the resulting cenospheres depended upon the furnace temperature.

Further studies led to the conclusion that there is, at least for cold-wall furnaces, a critical upper limit to the desirable size of burning particles. Coal preparation with bituminous coals does not end in the mill, but continues through the ignition zone. Experience has indicated that high combustible losses in the fly ash can sometimes be eliminated by changes in burner conditions and such improvement may be quite out of proportion to the increased time made available for combustion. Laboratory investigations indicate that such changes are those which would avoid formation of excessively large cenospheres.

The relation of burner conditions and coal size distribution to the radiating power of the flame is one of the outstanding problems associated with the use of pulverized coal. As applied to steam boiler furnaces, the portion of the total heat transformed by flame radiation is an important factor in controlling superheat temperature, some control having been obtained by shifting the position of the flame in the furnace.

Combustion Under Pressure

Development of the gas turbine has caused widespread interest in combustion under pressure. In this connection, the cost of large pressure vessels, often coupled with space limitations, demands that combustion chambers for the open-cycle gas turbines be operated at high ratings. Burning rates for pulverized coal in experimental units have been reported as high as 4,000,000 Btu per cu ft per hr. Such ratings should not be compared with those obtained in large steam-boiler furnaces where slagging conditions are a controlling factor.

(Continued on page 52)

Coal Research Report Issued by Mines Bureau

Increased utilization of native low-grade coals to offset growing shortages of high-quality fuels, and greater economy and efficiency in governmental, industrial and domestic fuel-using operations, were among the principal objectives of a widely ranging coal research program carried on last year by the U. S. Bureau of Mines. The findings are contained in Information Circular 7417 just issued and bearing the title "Annual Report of Research and Technologic Work on Coal."

Revealed was a deposit of 5 million tons of lignite in Washington, minable at low cost by strip-mining methods. Analyses of Colorado deposits indicated coal equal to the best previously known western cokingcoal—a major economic factor in the development of the western steel industry. Explorations also were conducted in Alaska for coal necessary for regional use, in Alabama for coking coal, and in Maryland for semi-smokeless coal of coking quality. The Bureau also intensified its survey of the carbonization properties of American and foreign coals.

Again placing its long-established fuel-economy and boiler-efficiency services at the disposal of Government agencies and private consumers, the Bureau last year advised fuel users in the purchase and utilization of fuels and fuel-burning equipment, achieving substantial savings both in coal and equipment costs. During the year, more than 15,000 samples were tested as a part of the coal-dust control program, in connection with Government purchases and tipple and breaker inspection, and in examining related materials in research work.

Pilot Plants for Producing Oil from Coal

Continued heavy requirements for petroleum and petroleum products and declining discoveries of new oil reserves gave added impetus to the Bureau's research development and demonstration plant program for producing synthetic liquid fuels from coal, oil shale and other substances. One of the four major installations authorized by the Synthetic Liquid Fuels Act (Public Law 290)—an oil-shale demonstration plant at Rifle, Colo.—has recently been completed. Designed to produce up to 500 barrels of oil per day, the plant has been in operation since May 1947. Two processes for producing oil and gasoline from coal are now being studied at Bureau projects in Pittsburgh and Bruceton, Pa., and in Morgantown, W. Va. Equipment now in operation permits the production and testing of catalysts, preparation of coal, gases,and other raw materials for the processes and the operation of two complete units of equipment for the continuous synthesis of oil and gasoline from coal. A demonstration plant capable of producing 200 barrels of oil a day by hydrogenation of coal is now being constructed on the site of the Government-owned synthetic ammonia plant at Louisiana, Mo.

Four years of study involving the use of 30,000 tons of coal proved that sub-bituminous coal can be stored without danger of spontaneous heating and little loss in heating value by using simple methods to prevent air circulation in the storage pile.

The Bureau has also issued Technical Paper 696, containing analyses of Arizona, California, Idaho, Nevada and Oregon coals. Coal is found at many scattered localities in these states, but in most of the known occurrences thick coal beds are of small extent and the coal generally contains a high percentage of impurities. Original reserves of coal in Arizona have been estimated by the Geological Survey at 15,060,000,000 net tons; in California and Oregon at slightly more than 1,000,000,000 net tons, and in Idaho and Nevada at 700,000,000 net tons.

In general, the coals are of sub-bituminous or lignitic rank, and the nature of the deposits require high-cost development and mining, precluding commercial competition with higher-rank coals of other states and with natural gas and oil.

Program of Joint Fuels Meeting at Cincinnati, October 20-21

The Tenth Annual Joint Meeting of the Coal Division, A.I.M.E. and the Fuels Division, A.S.M.E., will be held at the Hotel Gibson, Cincinnati, October 20 and 21. The tentative program is as follows:

Monday, 10 a.m.

"Performance of the Cyclone as a Thickener of Coal Slurry," by H. F. Yancey and M. R. Geer, U. S. Bureau of Mines.

"The Dorrance Colliery Cleaning Plant," by T. R. Workman and H. D. Bowker, West Virginia Coal & Coke Corporation.

Monday Luncheon, 12:30 a.m.

D. C. Weeks, Consolidated Edison Company of New York, *Chairman*.

Motion Picture—"The Continuous Discharge Spreader Stoker," shown and discussed by Otto de Lorenzi, Combustion Engineering Company.

Monday, 2 p.m.

"Stability of the Atmosphere and Its Influence on Air Pollution," by H. F. Hebley, Pittsburgh Consolidation Coal Company.

"Significance of Condensation Nuclei in Atmospheric Pollution," by Dr. Hans Neuberger, Pennsylvania State College.

"The Relation of Free Swelling Indexes to Other Characteristics of Some Alabama Domestic Stoker Coals," by R. Q. Shotts, State Experiment Station, University of Alabama.

Monday, 6:30 p.m.

Cocktail Hour.

Monday 7 p.m.

Banquet—J. E. Tobey, *Toastmaster*

Talks by M. H. Fies, Alabama Power Company and W. C. Schroeder, U. S. Bureau of Mines, on "Underground Gasification at Gorgas, Ala."

Tuesday, 9:30 a.m.

Panel Discussion on "Design and Operation of Small Coal-Fired Boiler Plants:"

1. "Relation of Fuel to Proper Equipment Operation," by C. A. Reed National Coal Association.
2. "Application of Anthracite Stokers," by P. F. White and C. F. Golding, Anthracite Institute.
3. "Application of Bituminous Stokers," by H. L. Wagner, Detroit Stoker Company.
4. "Design of Plants from a Consulting Engineer's Viewpoint," by H. N. Hermann, Harold N. Herman Associates.
5. "Instruments and Combustion Control for Plants," by W. H. Pugsky, Hays Corporation.
6. "Economics of Boiler Room Operation," by C. E. Miller, Assistant chief, Utilities Operations Branch, Chief of Engineers Office, Washington, D. C.
7. "Effect of Proper Application of Combustion Equipment in Smoke Elimination," by H. B. Lammers, Coal Producers Committee for Smoke Abatement, Cincinnati.
8. "Experiences with Government Operated Plants," by J. F. Barkley, U. S. Bureau of Mines.

Tuesday Luncheon, 12:30 p.m.

Evan Evans, Lehigh Navigation Coal Company, *Toastmaster*

Speaker—Ollie M. James, Editor and Columnist, Cincinnati Enquirer. Subject: "Just an Innocent Bystander."

Tuesday, 2 p.m.

"Estimates of Moisture Increase Due to Water Spraying Coal for Dust Control," by A.I.M.E. Coal Preparation Committee, T. W. Guy, chairman.

"Sectionalizing Power Distribution Underground," by A. L. Barrett, Pittsburgh Coal Company.

"A Look at Ohio's Fuel Situation in 1947," by R. F. Stilwell, North American Coal Corporation.

All sessions and social functions will be held at the Hotel Gibson and opportunity will be afforded for several interesting inspection trips to plants and other points in and around Cincinnati.

Eighth Annual Water Conference

The Eighth Annual Water Conference, under the sponsorship of the Engineers' Society of Western Pennsylvania, is scheduled for November 12–14 at the Hotel William Penn, Pittsburgh. As before, H. N. Olson is general chairman in charge of arrangements. The schedule of technical papers has just been announced as follows:

Wednesday Morning, November 12

Chairman—S. F. Whirl, Duquesne Light Company.

"Experiences with Frequent Acid Cleaning of Power Plants," by S. K. Adkins, Omaha Public Power District. Discussers: Raymond Davis, Kansas City Power & Light Company, P. H. Caldwell, Dowell, Inc., Darrel Sage (or representative) Public Service Corp. of New Jersey, O. B. Dick, Consolidated Edison Company of New York.

"Removal of Silica Deposits from Steam Turbines by Caustic Soda," by I. B. Dick, Consolidated Edison Company of New York. Discussers: W. L. Webb, American Gas & Electric Company, G. B. Warren, General Electric Company, Harold Farmer, Philadelphia Electric Company, and S. K. Adkins, Omaha Public Power District.

Wednesday Afternoon, November 12

Chairman—F. R. Owens, C. W. Rice Company

"Use of X-Rays in Water Problems," by Dr. L. A. Burkhardt, Allis Chalmers Mfg. Company. Discussers: H. W. Rinn, Dow Chemical Company, S. S. Sidhu, University of Pittsburgh, R. K. Scott, Hall Laboratories, and R. C. Corey, U. S. Bureau of Mines.

"The Biological Reactions of Polluted Waters on Copper Bearing Alloys," by C. O. Evans, Phelps Dodge Copper Products Corporation. Discussers: R. F. DeLong, Marathon Paper Company, J. G. Dobson, Wallace & Tiernan Company, and S. T. Powell, Baltimore, Md.

Thursday Morning, November 13

Chairman—Max Hecht, Consulting Engineer

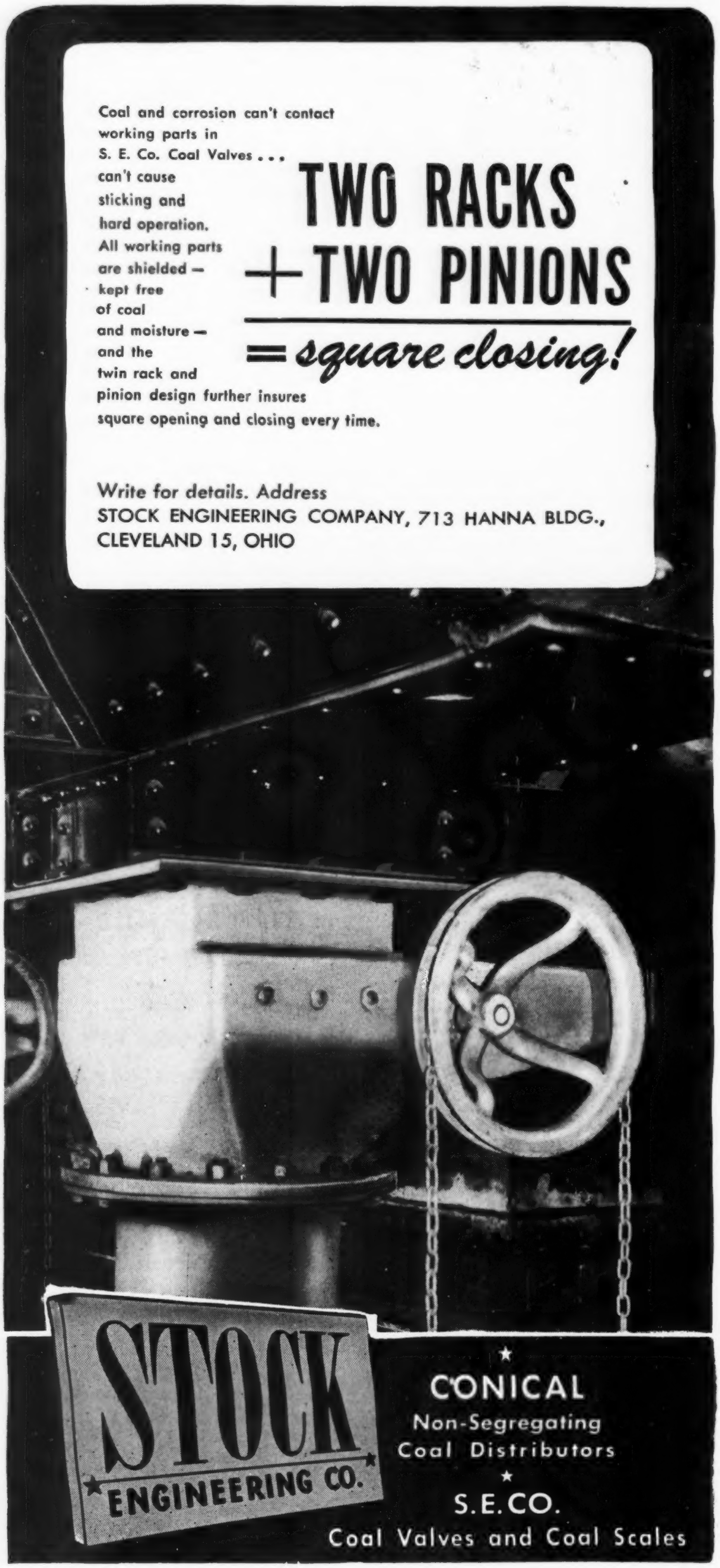
"Treatment of Brackish Feedwater," by O. M. Elliott, Sun Oil Company. Discussers: John Campobasso, E. B. Badger & Sons Company, Robert Adams, U. S. Naval Experiment Station, and S. T. Powell, Baltimore, Md.

"The Heat Exchange Method of Oxygen Determination in Boiler Feedwater," by J. F. Sebald, Worthington Pump & Machinery Corporation. Discussers: R. C. Ulmer, E. F. Drew Company, F. U. Neat, Consolidated Gas & Electric Company, R. C. Adams, U. S. Naval Experiment Station, and R. E. Hall, Hall Laboratories.

Thursday Afternoon, November 13

Chairman—H. M. Olson, Ohio Salt Company

"Silica Removal by Means of Ion Exchange Resins," by A. V. Alm, American Cyanamid Corporation. Discussers:



P. C. Goetz, Refinite Corporation, S. Sussman, Liquid Conditioning Company, R. W. Dwyer, Barnstead Still & Chemical Company, and J. W. Anderson, W. J. Westaway Corporation.

"Some Practical Aspects of De-Ionization," by Joseph Thompson and F. X. McGarvey, Resinous Products & Chemical Company. Discussers: Sidney Sussman, Liquid Conditioning Corporation, J. F. Wilkes, Dearborn Chemical Company, H. M. Mueller, McKays Company, and W. S. Morrison, Illinois Water Treatment Company.

"A Review of Field Performances on Methods of Removing Silica as discussed at symposium held at 7th Water Conference." W. W. Jukkola and R. B. Thompson, Dorr Company, M. E. Gilwood, Permutit Company, W. C. Bauman, Dow Chemical Company, and W. S. Morrison, Illinois Water Treatment Company, and V. J. Calise will also take part in this discussion.

Thursday Evening

Annual Banquet. E. T. Sterne, Toastmaster. Subjects and speakers and other information available later.

Friday Morning, November 14

Chairman—Owen Rice, Hall Laboratories

"Liquid Chemical Feed Systems," by R. T. Sheen, Milton T. Roy Company. Discussers: H. C. Beohner, Permutit Company, representative from Proportioneers, Inc., C. E. Joos, Cochrane Corporation, and A. C. Embshoff, Infilco, Inc.

"Automatic Control in Corrective Water Treatment," by W. N. Greer, Leeds & Northrup Company. Discussers: D. J. Saunders, Permutit Company, S. S. McKinney, Carnegie Institute of Technology, E. B. Showell, Du Pont Company, and C. H. Fellowes, Detroit Edison Company.

Friday Afternoon, November 14

Chairman—W. J. Murdoch, Consulting Engineer

"Pennsylvania's Stream Pollution Program," by L. S. Morgan, Department of Health, State of Pennsylvania.

"How Some Troublesome Waste Water Problems Were Solved," by A. C. Embshoff, Infilco, Inc. Discussers: L. K. Herndon, Ohio State University, and W. W. Hodge, Mellon Institute for Industrial Research.

"Engineering Studies for Industrial Waste," by G. A. Rohlich, University of Wisconsin. Discussers: L. D. Betz, W. H. and L. D. Betz, and D. E. Bloodgood, Purdue University.

Hearing on Pressure Vessel Code

The Boiler Code Committee of the A.S.M.E. is planning to hold a public hearing in New York City, November 19, at 10 a.m. in the Engineering Societies Building, on the new draft of the A.S.M.E. Unfired Pressure Vessel Code. Public hearings have already been held in Houston, Tex. and Los Angeles, where some 250 representatives exchanged views on the proposed revisions.

Thermometric Standard

A new thermometric standard utilizing the freezing point of benzoic acid as a fixed temperature has been developed and made available to industrial and other laboratories by the National Bureau of Standards. The acid, which is specially purified for the purpose, is contained in a cylindrical chamber, about 12 in. long and 2 in. in diameter, provided with a thermometer well. This device, known as a benzoic acid cell, affords a means of calibrating platinum resistance thermometers and thermocouples at a temperature near 100 C more rapidly and conveniently and, under certain conditions, more accurately than is possible with the boiling point of water. The temperature provided by the cell is virtually the triple point of benzoic acid (122.362 C).

The boiling point of water is well established as a fixed point in thermometry not only for historical reasons but also because the thermal properties of water and its ease of purification make it an almost ideal standard substance. The laborious barometric measurements required for accurate observations of the steam point have constituted the principal drawback to the use of this temperature in thermometer calibration. Recently, however, as the result of an investigation of the properties of benzoic acid by F. W. Schwab and Edward Wichers of the Bureau, it has been found possible to use the freezing temperature of benzoic acid for this purpose with a precision comparable to that of the steam point as observed in most standardizing laboratories.

To use the cell, it is heated in an oven until the acid has melted and reached a temperature a few degrees above its freezing point. The cell is then shaken until the liquid begins to freeze, forming a mush of fine crystals; thereupon the cell is put in a Dewar flask to retard the rate of freezing. The resistance thermometer (or thermocouple) to be calibrated is placed in the well, and observations of resistance (or emf) are made for a period of one to two hours. After the first thirty minutes, the temperature of the cell is constant within 0.001 deg C for an hour or longer and is reproduced in repeated "freezes" within a maximum range of 0.002 deg C.

The freezing temperature of each cell issued by the Bureau is certified to an accuracy of ±0.003 deg C. However, this is an estimate of the uncertainty involved in fixing the temperature on the International Temperature Scale, and does not relate to the constancy with which the temperature is maintained in a given cell during the time necessary for observations or to the day-by-day reproducibility of the cell.

Certified cells may be obtained from the National Bureau of Standards for a fee of $100 each. An uncalibrated companion cell containing acid of lower purity is offered for $15; it is useful for practice in manipulation and for pre-warming of the Dewar flask. Cells are available with thermometer wells in three diameters, 8, 10 and 12 mm. The diameter that most nearly fits the instrument to be calibrated should be used.

Personals

Ralph A. Sherman, supervisor of the Fuels Division, Battelle Memorial Institute, has recently been made one of six new assistant directors of that institution.

Charles F. Steiger, formerly chief engineer of the Manufacturing Division of the Kroger Grocery and Baking Company, has joined the staff of Douglas M. McBean, Inc., consulting engineers of Rochester and New York City.

L. A. Weom has been appointed manager of the Pump Division of Fairbanks, Morse & Co., succeeding Arnold Brown. He has been an engineer with that company since 1929.

Walter L. Stutz has retired from the National Bureau of Standards after 35 yr. service. He was chief of the Engineeering Instruments and Mechanical Appliances Section.

J. N. Ewart has been made chief mechanical engineer of the Buffalo Niagara Electric Corp., succeeding C. C. Whelchel who has resigned. Mr. Ewart has been with the company for the past eighteen years and since 1945 has been superintendent of production.

H. J. Peterson of the Tennessee Valley Authority was recently elected Chairman of the Executive Committee of the East Tennessee Section, A.S.M.E.

Obituaries

J. E. Sirrine, well-known consulting engineer and senior partner of J. E. Sirrine & Co., of Greenville, S. C., died on August 7 at the age of 74 following a long illness. After graduation from Furman University, he for a time was employed as southern representative of Lockwood, Green & Co., and in 1902 founded his own engineering firm which over the years has designed many industrial plants and power plants in the South. He was a member of the A.I.E.E., the A.S.M.E. and the A.S.C.E.

Prof. Frank O. Ellenwood, head of heat-power engineering at Cornell University and well-known author of engineering books and an authority on steam, died on September 7 at the Strong Memorial Hospital, Rochester, N. Y. He was 69 years old.

Coming to Cornell as assistant professor of heat-power engineering in 1911, he was named to a full professorship in 1915 and since 1941 had occupied the John E. Sweet chair of engineering. In addition to his teaching he acted as consultant to engineering firms over a long period.

Dr. William E. Wickenden, retiring president of Case School of Applied Science in Cleveland, who was recently selected to represent the Engineers Joint Council on the United States Commission for UNESCO, died suddenly at Peterboro, N. H., on September 1.

New Super Alloys Discussed

Speaking at a dinner highlighting the four-day technical program of the A.S.M.E. Fall Meeting at Salt Lake City, September 1–4, Clyde E. Williams, Director of Battelle Memorial Institute and President of the A.I.M.E., told of a new group of super alloys which will soon be available to withstand higher temperatures and pressures and which will offer new potentialities for power generation.

"The gas turbine would not have been possible without the highly alloyed materials developed in the past 5 to 10 years to withstand high stresses and temperatures up to 1500 F," he said, "and now engineers are pushing beyond this figure and are seeking materials to withstand 1600 F and stresses as high as 20,000 psi.

"Thanks to the skill of the design engineer and to the success of the metallurgist, the aircraft industry during the war was able to supply the superchargers for engines of high-altitude fighters and bombers and the gas turbines for our jet planes. For the supercharger, disk materials must withstand a temperature of 1100 F under high stress, for which purpose chromium-nickel-cobalt-iron alloy, strengthened with such other elements as molybdenum, tungsten, columbium or titanium, is used. The gas turbine blades used in superchargers and jet engines may be subjected to temperatures reaching 1500 F."

A new series of alloys, based on high chromium content, is showing great promise, according to Mr. Williams. One of these contains 60 per cent chromium, 15 to 25 per cent molybdenum and the balance iron. It must be melted and cast in a vacuum. In preliminary tests it is reported to show up better than cobalt-base alloys and gives promise of permitting safe use of still higher stresses than those now employed.

Welding Society Annual Meeting

The American Welding Society has completed the tentative program for its twenty-eighth Annual Meeting to be held October 19–24 at the Hotel Sherman, Chicago, during the National Metal Exposition. A total of 70 papers covering sixteen classifications of welding applications and research will be presented at the twenty technical sessions during the week.

Highlighting the meeting will be President L. W. Delhi's reception on Sunday evening, October 19; the Adams Lecture by G. S. Mikhalapov, Manager, Apparatus Research, Air Reduction Sales Co., and the awards of prizes and medals on Monday evening, October 20; the University Research Conference, Tuesday evening, October 21; the Section Conference, Wednesday evening, October 22; and the Annual Banquet on Thursday evening, October 23.

In addition to the technical sessions of the Society there will be welding and cutting exhibits at the National Metal Exposition to be held at the International Amphitheatre, Chicago.

Development, Manufacture, and Calibration of Standard Flow Nozzles

The Heat Exchange Institute has issued a pamphlet describing the background of a project undertaken by the Steam-Jet Ejector and Vacuum-Cooling Section of the Institute to provide standardized flow nozzles for the measurement of air flow in the steam-jet ejector industry.

In the development of these standards, the Institute realized that home-made nozzles could never be uniformly dependable and that their manufacture was clearly a job for the experienced instrument maker. It therefore decided to finance the development of standard flow nozzles for all of its interested members, and an order for twenty-four sets, in accordance with exacting specifications, was therefore placed with the American Instrument Company, Silver Springs, Maryland.

Further, the Institute realized that a true standard could not be had without calibration by a competent and recognized authority and it therefore contracted to have ten sets of these nozzles, selected at random, and calibrated by the National Bureau of Standards.

Moreover, to give this program publicity, Heat Exchange Institute is making copies of the pamphlet available for general distribution free of charge. Copies may be had by writing to: Heat Exchange Institute, 90 West Street, New York 6, N.Y.

BOOKS

1—Explosion and Combustion Processes of Gases

By Wilhelm Jost

Translated by Huber O. Croft

621 pages Price $7.50

This book is primarily a work of reference for those engaged in research in combustion, detonation and explosion, and an idea of its scope can perhaps best be had by enumerating the successive chapters. These are: Initial stages of explosions as a thermal phenomenon; thermal theory of spark ignition; propagation of explosions (including limits of ignition, normal velocity of combustion and influence of mixture); explosions in closed chambers; detonation; flames of gases not premixed; flame temperatures; radiation investigations of flames; kinematics of combustion; combustion of oxygen-hydrogen mixtures and of carbon monoxide; spark ignition; combustion of hydrocarbons (both in the flame and by slow oxidation); the ignition of hydrocarbons at high pressures; and combustion in both the Otto and diesel cycles.

2—A.S.T.M. Methods of Chemical Analysis of Metals

412 pages 6 × 9 Price $4.50

The 1946 Book of A.S.T.M. Methods of Chemical Analysis of Metals, which replaces the earlier 1943 edition, gives in their latest form the 35 extensive standards developed by the A.S.T.M. committees concerned with the analyzing of metals and their alloys. This greatly expanded volume includes not only modernized versions of the various older methods widely used throughout industry, but it includes several of the newer photometric methods and also spectrochemical methods of analysis for certain materials and elements.

There are recommended practices covering apparatus and reagents and photometric methods; methods of sampling and chemical analysis of steel, cast iron, wrought iron, etc., are included, together with methods of sampling and analyzing ferro alloys. A considerable portion of the new volume is devoted to nonferrous metals, including sampling, chemical analysis and photometric method covering aluminum, magnesium, copper, lead, lead and tin-base alloys, solders, zinc and nickel.

3—Thermodynamics

By G. A. Hawkins

436 pages $8^1/_2 \times 5^3/_4$ Price $4.50

Drawing on his broad background in teaching at Purdue University, as well as in the practical application of thermodynamics in engineering, Professor Hawkins has turned out an excellent text. Emphasis has been placed on those concepts and applications that his experience has shown to be of most value to the engineer in the practice of his profession.

By adopting the current usage of solved problems to illustrate the points under discussion, clarity is imparted to both students and to engineers renewing their familiarity with the subject. This value of the book is further enhanced by a comprehensive and well-arranged index and by the inclusion of the fundamentals of heat transmission.

4—Applied Atomic Power

227 pages 6 × 9 Price $4.00

This book is written with the object of informing the layman in relatively simple language, that can be understood by careful reading, what atomic power is. It traces in an elementary way the development of atomic energy from early work in radioactivity to its present-day scientific status, and reviews the possibilities, in so far as we know them, of the application of atomic power to industrial progress.

The various terms, such as isotopes, transmutation, fission, chain reactions, moderator and pile, frequently referred to in connection with the subject of atomic or nulcear energy, are defined and explained. The physical background of atomic energy production in the earlier part of the book prepares the reader for the summary of the development of atomic energy leading to the atomic bomb, which is dealt with in the following section. This section gives a summary of the progress at various stages throughout the war period and includes an explanation of the separation of the uranium isotopes by various methods. The next section covers some possible methods of converting atomic energy into mechanical power and the last part of the book enumerates some of the benefits which industry might expect from the engineering principles, new and improved equipment and new methods that have been developed as a necessary prerequisite of the atomic bomb.

The appendices include a résumé of the work on the atomic bomb, a conversion table for energy units and a table of nuclear and atomic masses of isotopes.

5—Heating and Air Conditioning (6th Edition)

By J. R. Allen, J. H. Walker and J. W. James

667 pages 6 × 9 Price $5.50

This is an excellent and thoroughly up-to-date textbook. It offers the student or layman a solid theoretical ground-work in domestic and industrial heating and air conditioning and provides him with some knowledge of present practice.

No revolutionary changes have developed since the last edition of this book appeared seven years ago and much of the previous text has been retained. However, numerous additions and changes have been made to both text and illustrations to bring the book into complete accord with recent development and current practice. The chapter on Fuels and Boilers has been extensive revised, while those on Gravity Warm-Air Furnace Heating and Residence Air Conditioning have been revised to include the latest rating formulas and design procedures of the industry. A new section on panel heating is included and consideration is also given to the principle of a reversed-cycle refrigeration system.

The book is written in a clear and cogent style and covers all the essentials of the subject in 23 chapters, many of which include problems and a bibliography.

6—Fuels, Combustion and Furnaces

By John Griswold

496 pages 6 × 9 Price $5.50

This is essentially a textbook, written and arranged more particularly to meet the needs of students in chemical engineering.

The technology of fuels of various types, both natural and manufactured, is adequately covered, as is also the theory of combustion processes. Fuel-burning equipment and steam generation are briefly covered.

At the end of each chapter is a list of supplementary references and problems for the student.

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(*Continued from page 42*)

Slagging in the combustion chamber of a gas-turbine unit is controlled by the high excess air necessary to reduce the gas temperature to levels that can be tolerated in the turbine. This reduces the volume requirement to that needed for combustion and mixing with excess air. To what extent these two functions can be accomplished simultaneously is uncertain. Laboratory investigations suggest that combustion may be completed after dispersion into the excess air, provided proper conditions are attained at the burner.

These investigations were limited to relatively large particles at atmospheric pressure, but they are now being extended to higher pressures by T. T. Omori, who was also responsible for the observations on ignition of supported particles in the micro furnace.

Preliminary data now available indicate that the furnace temperature required to bring about ignition is not particularly dependent upon pressure. While there is an increase in the rate of burning, it is probably not in full proportion to the partial pressure of oxygen. Cenosphere formation has been observed with coal of 170 to 200 mesh, furnace temperature up to over 1800 F and pressures of 150 psi. Though the degree of combustion seems to be somewhat higher under pressure, there seems to be the same tendency for particles to stop burning as they move out of the more intense parts of the flame. This would indicate a need for greater flame intensity near the ignition zone rather than increase in combustion volume.

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